The following papers were read:—

1. On the Abdominal Viscera and a Vestigial Seventh Branchial Arch in *Chlamydoselachus*. By Mrs. O. A. Merritt Hawkes, M.Sc. (Zoological Laboratory, University of Birmingham).*

[Received March 23, 1907.]

(Text-figures 138, 139.)

Introduction.

The following notes on the abdominal viscera of *Chlamydoselachus anguineus* (Gar.) are published, because the first writer on this species, Garman (1), had only a partly eviscerated female, and the second writer, Günther (2), gave only a general description which does not make note of the distinctive characteristics of *Chlamydoselachus*. On some points, my specimens did not agree with either that of Garman or those of Günther.

As the heart has already been described by both Günther and Garman, it has not been necessary to make any further reference to that organ.

In this paper, an attempt has been made to look upon the alimentary viscera from the functional as well as the anatomical point of view, hence suggestions have been made to attempt to explain certain Chlamydoselachian peculiarities.

Garman has given a description and a figure of the branchial arches, but in his specimen there was obviously no trace of the vestigial seventh arch. It is probable that this arch and its nerve-supply † are of a very variable character, as is frequently the case with vestigial structures.

The Alimentary Canal.

The general arrangement of the alimentary canal in *Chlamydoselachus* is, in most of its features, typically Elasmobranchian.

There are thirteen rows of teeth on each side of the upper and lower jaws, making a total of 52 rows, instead of 51 as stated by Garman (1). The arrangement is, as would be expected, bilaterally symmetrical. In every specimen examined, however, there was a torsion of the left front row of teeth towards the right side; and in one case this resulted in a median row of teeth as described by Garman, but the total number of rows of teeth was still 52.

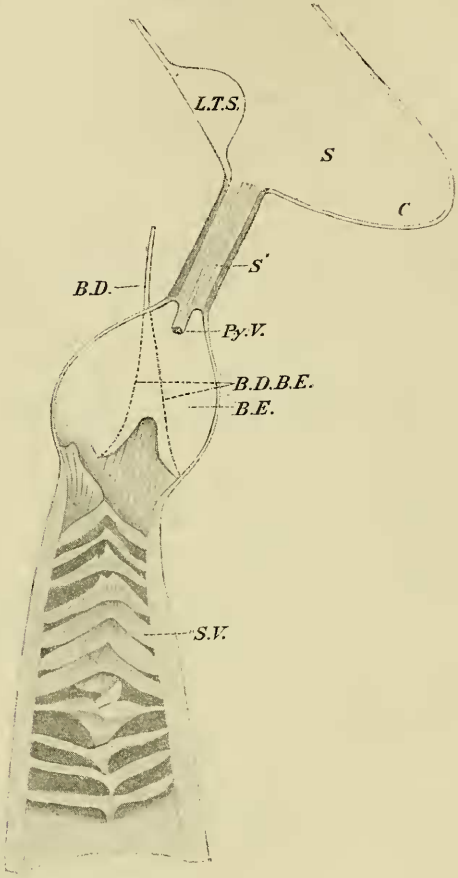
Garman found six functional teeth in each row, but the specimens examined by me had generally five, although in some cases six.

* Communicated by Professor Bridge, F.Z.S.

† See Proc. Zool. Soc. 1906, p. 983.

The mouth is succeeded by the pharynx into which open the six pairs of branchial clefts, the first of which is 1 cm. longer than

Text-fig. 138.



Alimentary canal from the middle of the stomach to the middle of the colon of *Chlamydoselachus*.

Reference Letters.

B.D. Bile-duct.
B.D.B.E. Dotted lines showing the position of the apparently enlarged end of the bile-duct in the walls of the bursa entiana.
B.E. Bursa entiana.
C. Cæcum at the hinder end of the larger arm of the stomach.
L.T.S. Thickening of the stomach wall, probably due to a lymphatic gland.
Py.V. Pyloric valve.
S. Stomach.
S′. Short arm of the stomach.
S.V. Spiral valve.

the others. A wide and very distensible œsophagus follows, and this passes without any external mark of differentiation into the stomach. This organ is U-shaped, one arm being much longer than the other, which is, at first sight, scarcely noticeable. The longer arm of the stomach (text-fig. 138, S) ends in a small cæcum (C). Opposite the cæcum, the stomach-wall is thickened, perhaps by a lymphatic gland (L.T.S.). This thickening, on account of its position, would probably function as a valve between the two arms of the stomach. The walls of the stomach are irregularly corrugated. The shorter arm of the stomach (S′) differs from the larger anatomically and functionally. It is a short, thick-walled tube incapable of distension, the lining mucosa of which is raised into parallel ridges. This arm opens into the intestine by a protruding pyloric aperture (Py. V.) which is furnished with distinct sphincter muscles. The relatively narrow lumen of the shorter arm of the stomach, combined with the action of the pyloric sphincter, acts as an efficient guard against the passage of large pieces of partly digested food into the colon. Anything but a semi-liquid chyle might produce a serious obstruction in the course of the long and complicated spiral valve.

The bile-duct (B.D), which traverses the anterior division of the spleen, becomes joined to the anterior part of the "bursa entiana" (B.E). It then rapidly enlarges, and finally opens into the bursa by an aperture the diameter of which equals the semi-diameter of the latter. The terminal third of the duct has its lining mucosa raised into parallel striæ which are continuous with those seen in the first part of the colon. This suggests that the region which appears to be the terminal portion of the bile-duct is, in reality, an evagination of the colon towards the bile-duct. Owing to the presence of the striæ, the bile must pass backwards towards the spiral valve and not forwards into the bursa entiana. The bursa, which is a thin-walled sac, may serve as a distensible receptacle for the partly digested food before it is passed on in small quantities into the comparatively inelastic colon. The pancreatic duct opens into the region where the spiral valve begins; hence, although gastric digestion may continue in the bursa, intestinal digestion cannot begin until the food reaches the spiral valve. The so-called colon has thick walls. Its shape is that of a double cone, the widest part varying in position, but in both of my specimens it was near the region of the contorted coil. The widest part has the thickest walls. In the specimen examined the spiral valve had 43 coils (text-fig. 138). The valve at the very beginning is a well developed ridge, but at the end it tails off gradually. In the specimen figured by Günther (2) there were only 35 turns, whilst the valve both began and ended gradually. In both Günther's specimen and that under discussion, the anterior cone-like coils pass forwards, the posterior backwards. Both specimens have an intermediate region of one coil in which the valve is contorted. Of the 35 coils in Günther's specimen 19 pass forward, one is contorted, and 15 pass backwards; of the 43 coils in my specimen

7 pass forward, 1 is contorted, and 35 are directed backwards. In all the species of Elasmobranchs which Parker (3) described there was a much smaller number of coils which were either directed forwards or backwards continuously. He states, however (p. 49), that " in a smaller specimen of the same species (*Scyllium canicula*), there were 8 turns to the valve, of which 5 had a forward and the last 3 a backward direction." This condition was exceptional in the species named. It is not improbable that the twofold direction of the valves in *Chlamydoselachus* has some physical relation to the large number of coils. It can have no relation to the length of the colon, as this is not relatively longer than in the majority of Elasmobranchs. On the other hand, the twofold direction may have a special physiological significance. Where the valves are directed forward, the passage of the food is undoubtedly slower than where they are directed backwards.

In *Chlamydoselachus* the coils of the spiral valve are closer to one another, and the valve is broader, in the anterior than in the posterior region. The anterior valves are covered by numerous well-defined striæ. The valve reaches a breadth of three-fourths of the diameter of the colon in the anterior region, which is, *par excellence*, the region of intestinal digestion. Owing to the anterior direction of the valves, the movement of the food is slow, and it is further hindered by the contorted coil which divides the colon into two physiological parts. Absorption takes place in the posterior part where the valves are directed backwards, and where there is comparative rapidity of movement. In this region, the striæ are absent, except on the first 7 coils where they are few and inconspicuous.

The spleen is interesting in that it is divided into two parts which are separated by a space of 4 cm. The additional lobe is situated to the right of the stomach and somewhat dorsally. It is an ovoid body, 3 cm. long and nearly 2 cm. broad in the widest part, and is situated between the stomach and a fold of mesentery which supports the latter. The other part or spleen proper lies in the usual place at the angle of the stomach. The histological characters of the spleen proper when examined by a low-power lens present the usual appearace, but the structure of the additional lobe is much more compact.

The rectum has thin and much wrinkled walls. Its diameter is slightly greater than that of the adjacent portion of the colon. The rectal gland opens into the rectum in the mid-dorsal line, 1·5 cm. beyond the end of the colon. According to Günther the gland opens into the cloaca, but it certainly did not do so in the two specimens examined by me.

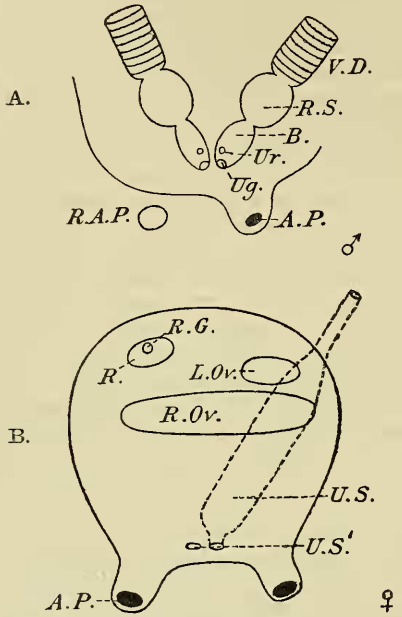
The liver consists of right, left, and median lobes. The gall-bladder is situated in the median lobe. The length of the lobes necessitates their being doubled forward upon themselves. In one specimen, the end of the left lobe was lying on the right side of the body-cavity.

The Urogenital Organs.

The Female.—The ovaries are diffuse bodies attached by broad mesenteries to the line of attachment of the "stomach" mesentery. The right ovary is placed somewhat more anteriorly than the left. The oviducts have large funnels which open ventrad to the stomach, instead of dorsad as is usually the case. The edges of the funnels are irregular and spreading, and are united in the median ventral line to one another, thus forming one large funnel. The anterior edges of the funnels become united to the anterior wall of the body-cavity, whilst the posterior edges of the united fimbriæ hang free. A triangular dorsal pouch is thus made between the wall of the abdominal cavity and the funnel. As this pouch is in the usual position of the cœlomic openings of the oviduct, the eggs would tend to pass into it instead of into the latter, if this were not prevented by the unusual position of the ovaries which are ventral to the oviducts. For the first 6 cm. the oviduct is a straight tube, the walls of which are lined with numerous laminæ. This region passes into the oviducal gland, the walls of which are much thickened, except along two longitudinal lines which are approximately dorsal and ventral. The length of the gland is 3 cm. Its interior is covered by fine laminæ *continuous* with those in the preceding and succeeding portions of the oviduct. The laminæ run spirally, and are very close together, instead of longitudinally and somewhat separated, as is the case throughout the remainder of the oviduct. The transverse deeper groove in the oviducal gland mentioned by Garman (1. p. 20) was found in the specimen examined. Passing from the oviducal glands, the oviducts regain their original diameter, but the walls are smoother, the laminæ being reduced to slight striæ. When the oviduct reaches the level of the anterior end of the colon, it enlarges. The enlargement is gradual and only increased in diameter about fourfold on the left side, but on the right the enlargement is sudden and very apparent, the diameter increasing 14 to 15 times. This region in addition to being enlarged has folded walls, in which occur one large and several small areas of dilated blood-vessels. The largest blood-plexus occupies about one-third of the right side of the oviduct. In connection with each plexus, on its dorsal side, the oviducal wall is thickened over an area which equals the plexus in length and breadth. The enlarged vessels apparently supplied these thickened areas. The condition of the oviduct thus described suggests that this portion of the oviduct acts as a functional uterus, and that therefore *Chlamydoselachus* produces the young alive, as suggested by Garman. The final portion of the oviduct, which succeeds the uterine, has smooth walls and a large diameter, the latter gradually diminishing towards the cloaca. This region divides the functional uterus from the cloaca, thus functionally representing the vagina of higher types. The opening of the right enlarged oviduct (text-

fig. 139, R.Ov.) has acquired a median position, the left oviducal opening (L.Ov.) lying cephalad to it. Garman also found that one oviduct was much enlarged but does not mention which, but from his drawing (1. pl. xix. fig. 2) it appears to have been the right. Günther does not mention the female reproductive organs.

Text-fig. 139.



Diagrammatic figures of (**A**) male and (**B**) female cloaca of *Chlamydoselachus*.

Reference Letters.

A.P. Closed abdominal pores.
B. So-called "bladder" (urinary sinus).
L.Ov. Left oviducal opening.
R. Rectum.
R.A.P. Functional right abdominal pore.
R.G. Opening of rectal gland into rectum.
R.Ov. Right oviducal opening.
R.S. Seminal vesicle.
Ug. Urinogenital opening.
Ur. Opening of ureter into urinary sinus (B).
U.S. Urinary sinus of female.
U.S'. Openings of urinary sinuses into the cloaca.
V.D. Vas deferens.

Transverse sections through the thickened areas of the uterus show that the lining membrane is much folded and is entirely covered by a columnar epithelium, the cells of which have a distinctly granular appearance. It is impossible to state definitely

whether any glands homologous with uterine glands of higher forms are present, but it is highly probable that all the granular columnar cells secrete a fluid. The musculo-fibrous tissue of the uterine wall is greatly thickened owing to an increase of connective tissue in which connective-tissue corpuscles abound *.

The kidney in the female is thin dorso-ventrally and of irregular breadth. It extends from the region of the oviducal gland to the end of the body-cavity, gradually widening as it passes backwards in a sinuous line. The sinuosity is due to the arrangement of some of the dorsal muscles. Cephalad to the kidney and apparently unconnected with it, there is an irregular body (1·5 cm.) which extends somewhat beyond the end of the abdominal cavity. This is probably the head kidney (pronephros ?), which in the adult has retained its position in the region to which the cœlom extended in the embryo.

There are two very small cloacal apertures for the urinary sinuses (text-fig. 139 B, U.S'.) in the specimen examined, although Garman only found one in his (**1**. p. 20). They are situated in the median line near the external opening of the cloaca. The openings are near together but can hardly be mistaken for one. Each aperture passes into an expanded chamber (U.S.) with laminated walls, the lumen of which has a diameter of 5 mm. in the cloacal region. The first portion of the sinus is embedded in the thick cloacal walls. Each sinus extends forwards for a distance of 6 cm. beyond the cloaca along the inner side of the kidney, but in front of this point it lies near the oviduct, at a distance from the kidney varying from 1 to 2 cm. The same mesentery which supports the oviduct also supports the urinary sinus and the mesonephric ducts. The latter pass from the kidney at regular distances, there being approximately one to each myotome.

In the female cloaca the rectal aperture is displaced to the right, and the same deviation, but to a much less degree, occurs also in the male.

The Male.—In the male there are two urogenital apertures (text-fig. 139 A, Ug.), each of which is the outlet of an oval urogenital sinus (B.), which Günther described as a urinary bladder. The sinus communicates by a very small aperture with a second and larger chamber (R.S.), which possibly functions as a seminal vesicle, and in front has opening into it the vas deferens or mesonephric duct (V.D.). The vas deferens has one or more projecting spiral folds, which run from one end of the duct to the other. For the last 10 cm. of the length of the duct the folds were very obvious, but from this point forwards they become almost invisible to the naked eye. The folds are so close together in the

* Since this paper was read, I have received a letter from Mr. Kumakichi Aoki, of the Zoological Station at Miura Misaki, stating, in answer to some questions, that eggs are not laid and that he has lately had two females, each of which contained five embryos, in one case measuring one foot each and in the other one inch. Each very young embryo with its large yolk-sac was surrounded by a gelatinous sac, no doubt the remnant of the egg envelopes.

posterior part of the duct that Günther speaks of an annular lining. The function of the folds, which, in all probability, is to pass along the sperms, and possibly at the same time to unite them into bundles, could scarcely be effective, however, if the folds were annular. The lumen of the left vas deferens, which Günther found to be better developed than the right in one specimen, is very irregular in diameter in my specimen. At its widest the duct is about 5 mm., but where narrowest it only allows the passage of a bristle.

One of the males examined has two abdominal pores (text-fig. 139 A, A.P., R.A.P.), of which the right is the better developed. This condition differs from that described by Günther (2. p. 4), in which the left pore only was present.

A Vestigial Seventh Branchial Arch.

Three specimens were dissected to determine if there were any trace of a seventh arch. Traces were found in two of the specimens, one of which was not quite full-grown.

The remnants in the smaller specimen consist of four small pieces of cartilage on one side and two on the other. These lie close to the cerato-branchial of the sixth arch, on the posterior side, nearer its median extremity. In the adult specimen in a similar position there are two pieces, the larger of which equalled in length the combined four pieces found in the smaller specimen.

Bibliography.

1. Garman, S.—"*Chlamydoselachus anguineus* (Gar.)—a Living Species of Cladodont Shark." Bull. Mus. Comp. Zool. vol. xii. no. 1. p. 1. 1885.
2. Günther, A.—*Chlamydoselache anguinea*. 'Challenger' Reports, vol. xxii. 1887, p. 2.
3. Parker, T. J.—"On the Intestinal Spiral Valve in the Genus *Raia*." Proc. Zool. Soc. 1880, p. 49.

2. Second Report on the Batrachians and Reptiles collected in South Africa by Mr. C. H. B. Grant, and presented to the British Museum by Mr. C. D. Rudd. By G. A. Boulenger, F.R.S., V.P.Z.S.

[Received May 3, 1907.]

(Plates XXI. & XXII.* and Text-figures 140, 141.)

Since the publication in these 'Proceedings,' two years ago (P. Z. S. 1905, ii. p. 248), of an annotated list of the Batrachians and Reptiles collected by him, Mr. Grant has continued his exertions in the same department, making collections in the following localities :—

I. Cape Colony. Knysna, 50 miles east of Mossel Bay.
II. Natal. Illovo, 30 miles S.W. of Durban.

* For explanation of the Plates, see p. 487.